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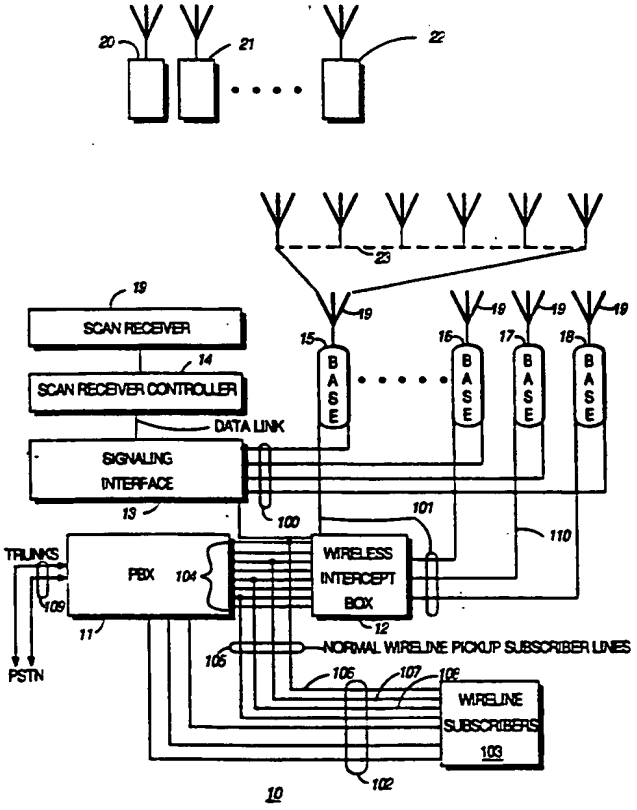
(54) Title: WIRELESS PBX SYSTEM USING FREQUENCY SCANNER FOR CHANNEL IDENTIFICATION

(57) Abstract

In a wireless private branch exchange (11), communication network (10), a method and apparatus are offered for identifying network communication resources. The method includes the steps of measuring a signal quality factor of a channel of a selected spectrum and comparing the measured values with a threshold value. The method further includes the step of selecting channels, exceeding the threshold, as network communication resources. The selected spectrum is that also used by a local cellular communication network. Where scanning determines that a channel is not used by the cellular system then use is permitted with the private system.



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WIRELESS PBX SYSTEM USING FREQUENCY SCANNER FOR CHANNEL IDENTIFICATION

Field of the Invention

The invention relates to communication systems and, in specific, to wireless communication systems used in conjunction with private branch exchange communication systems.

Background of the Invention

Private branch exchange communication systems (PBXs) are known. PBXs are commonly used where a discrete group of people (e.g., employees of a company) need to communicate, in large measure, within the group. A PBX, in providing service within the group, is typically limited to a fixed geographic area coincident with a company facility or group of facilities.

PBXs offer advantages in that calls between members of the discrete group are handled locally within the PBX and do not involve an associated public switch telephone network (PSTN). Such local handling reduces the cost of providing communication services within the group.

PBXs also provide other advantages, such as call blocking to specific numbers or groups of numbers. Call blocking, in such case, may be used by a PBX operator to prevent long-distance calls from specific telephones or groups of telephones within the private system.

Cellular communication systems are also known. Cellular communication systems, as opposed to PBX systems, are constructed to provide communication services over broad geographic areas through a number of base sites. Each base site within such a system is positioned to provide service within a service coverage area, partially overlapping adjacent service coverage areas, in such a manner as to provide substantially continuous coverage to a communication unit passing through such an area.

Communication service, within a cellular system, is provided to a communication unit on a radio channel selected from a number of communication channels (f_1-f_n) available

within the system. Such radio channel are assigned to communication units upon request.

Cellular communication systems are typically interconnected with the PSTN either locally, through an interconnect at each base station, or centrally, through a mobile switching center (MSC) that interfaces with a number of base sites. The interconnect with the PSTN allows a communication unit to communicate with subscribers throughout the PSTN as well as other communication units. The interconnect with the PSTN also allows a communication unit to communicate, through PBXs with telephone users within a PBX.

While both PBXs and cellular communication systems work well in their respective market niches, instances arise where it would be advantageous to combine a PBX with a local wireless service, coincident with the area of the PBX service. Such a combination would offer the advantage of providing wireless communication services within the confines of a manufacturing facility, office building, or shopping mall without the involvement of the PSTN.

Also, because a private wireless system may find it advantageous to use cellular channels, the private wireless system may have to coexist with existing cellular facilities. Such a wireless PBX communication system may have to be able to select channels also being used by a local cellular system. Because of the importance of PBXs and the need for wireless communication within a PBX environment a need exists for a means and method, of selecting cellular channels for use by a wireless PBX system, that is non-interfering with the cellular system.

Summary of the Invention

In a wireless private branch exchange, communication network, a method and apparatus are provided for identifying network communication resources. The method includes the steps of measuring a signal quality factor of a channel of a selected spectrum and comparing the measured values with a threshold value. The method further includes the step of selecting channels, exceeding the threshold, as network communication resources. The selected spectrum is that, also used, by a local cellular communication network. Where scanning and threshold comparisons indicates that a channel is not being used by the cellular system then use is permitted within the private system.

Brief Description of the Drawings

FIG. 1 illustrates, in block diagram form, a private branch exchange including a wireless communication facilities in accordance with one embodiment of the invention.

FIG. 2 illustrates, in block diagram form, a wireless intercept box in accordance with the invention.

Detailed Description of the Preferred Embodiment

The solution to the problem of channel selection within a PBX wireless communication system lies, conceptually, in the use of a scanner and in the evaluation of communication resources based on signal measurements by the scanner. Resource evaluation is based upon comparison of signal measurements on scanned resources with a threshold value. The use of a scanner allows candidate resources to be evaluated for interfering users before use is permitted within the PBX wireless system. Scanning, under such a format, may be of an entire spectrum with the results reported, en masse, to a wireless controller or scanning may be of individual resources under the control of the wireless controller with individual signal measurements reported back to the wireless controller for comparison with the threshold.

The reader's attention will first be drawn to a description of function of a wireless PBX system. Following the description of function, channel selection will be described in accordance with one embodiment of the invention.

FIG. 1 illustrates, in block diagram form, a PBX system, generally (10), offering wireless communication services in accordance with a preferred embodiment of the invention. Included within such a system (10) is a PBX switch (11), wireless interface box (WIB) (12), signaling interface (13), scan receiver controller (14), scan receiver (19), and base stations 15-18. Also shown in FIG. 1 are communication units 20-22.

PBX communication system 10 is constructed to have the functionality of routing telephone calls among subscribers (103) and external, PSTN subscribers (not shown) and among subscribers (103). A call from a wireline subscriber (103) to another wireline subscriber (103) is accomplished through interconnects (102) under prior art methods within the PBX switch (11). Calls between an external, PSTN subscriber and wireline subscriber (103) is also accomplished under prior art methods within the PBX switch (11).

Some subscribers (103), in accordance with one embodiment of the invention, have a dual service capability including the capacity of receiving (and making calls) through either wireline or wireless facilities. Such subscribers (103) receive wireline service through a wireline facility at a fixed location (e.g., a telephone within an office) or through a wireless transceiver (20-22) carried by the subscriber (103).

Such dual service capability is provided through use of the WIB (12) interconnected with normal wireline pickup subscriber lines (105). The WIB (12) provides the functionality of forwarding calls directed to a wireline subscriber on a wireline (e.g., 106) to a wireless receiver (e.g., 20) after a fixed delay. (Alternatively a call may be routed first to the wireless subscriber and then, after a delay, to the wireline subscriber.) The fixed delay allows for receipt of the call at the fixed location (through wireline 106) before transfer to the wireless communication unit (20) through the WIB (12) and a base station (15, 16, 17, or 18). Coupling between WIB (12) and base stations (15-18) is accomplished via

signaling links 100, incorporating a wireless-related signaling protocol, and via subscriber links 101.

Communication units 20-22 and base stations 15-18 are constructed to exchange communicated messages at low power levels (e.g., 10 milliwatts) under a prescribed signaling protocol such as, for example, that used in the Advance Mobile Phone Service (AMPS) cellular radiotelephone service. In accordance with the preferred embodiment, communication units 20-22, upon activation, scan a spectrum seeking a signal from any of base stations 15-18 for service through the PBX wireless system (10).

While base stations (15-18) are shown with a single antenna (19), the single antenna (19) of base stations (15-18) is comprised of a distributed antenna network (23) coupled to the base stations (15-18) through a combiner (not shown). Also coupled to the distributed antenna network (23) through the combiner is the scan receiver (19). The independent antenna of the distributed antenna (23) are located throughout a service coverage area of the PBX system (e.g., a floor of a building). Other distributed antenna (23) may cover the same, or other floors.

The distributed antenna (23) simplifies system design in that wireless subscribers (20-22) may progressively transceive through different antenna of the network (23) as the subscriber (20-22) moves through a coverage area of a base station (20-22). The distributed antenna (23) allows operation of the PBX wireless network (10) without the complicated process and associated hardware required by handoff from base station to base station.

FIG. 2 generally depicts, in block diagram form, WIB 12. As shown, wireline group 104 enters a time slot interchange (TSI 218). In the preferred embodiment, TSI 218 may be a time slot interchange as that having part number 8980, and manufactured by MITEL® (MITEL is a registered trademark of MITEL Corp., a subsidiary of British Telecom). Continuing, TSI 218 is also coupled to subscriber links 101 which interconnects WIB 12 to base stations 15-18. TSI 218 is interconnected to I/O) controller 215 which performs interfacing tasks between processor 206 and TSI 218. Processor 206 is coupled to a data store (209) which stores, inter alai, slot-to-slot connection data and subscriber line-to-wireless subscriber number translation. In addition,

processor 206 is coupled to a program store (212) which stores programs used by processor 206 to perform, inter alai, TSI control, signal digit analysis, and ring detection. Processor 206 is coupled, via I/O controller 203, to the signaling interface 13. Signaling interface 13 provides the requisite interface for signaling links 100 to inter-couple WIB 12 to base stations 15-18.

Signaling interface 13 accepts signaling information, from processor 206 from a selected line of wireline group 104, and uses this information for its own control and for generating the appropriate signaling messages for subscribers, for example, wireless subscriber 20. In addition, signaling interface 13 transmits and receives information to/from base stations 15-18. This data is primarily information which will be sent, or has been received, on a control channel, but the information content may be expanded as required. In the preferred embodiment, the type of signaling used in the system is analogous to that used in the AMPS cellular radiotelephone system. In alternate embodiment, signaling links 100 may carry information using a message based protocol between signaling interface 13 and base stations 15-18. Implementation of signaling interface 13 may be realized by employing any conventional micro-computer system. As such, in this embodiment, signaling interface 13 would also be able to maintain call records and statistics as required based upon the passage of information.

Base stations 15-18 of FIG. 1 each transmit overhead information, pages, and appropriate channel assignments to wireless subscribers (20-22), such as wireless subscriber 20. In the reverse direction base stations (15-18) receive page responses and call origination requests from wireless subscribers (20-22). Signaling links (100) can carry the above-mentioned information (between base stations (15-18) and WIB (12)) in the actual protocol message form as required by the wireless system, or it can be in any of the data link protocols (e.g., high-level data link protocol (HDLC)).

Referring to FIG. 1, WIB 12 has the capability to monitor the data stream of individual trunks from trunk group 109. In the preferred embodiment, trunk group 109 consists of a 24 channel pulse coded modulated (PCM), 1.544 megabit per second (Mbps), (DS1) service. In this scenario, the least significant bit of every sixth DSO slot contains signaling information pertaining to trunk seizure, called number, disconnect, etc. (For further

information, reference may be made to CCITT Bluebook specification G.704, G.733, and G.734, published November 25, 1988 in Geneva, Switzerland.) Signaling information, from trunk group 109, is assembled in message format and is transferred to signaling interface 13 using a protocol such as HDLC. The message content can be set-up in a "1" or "0" format for interpretation in signaling interface 13.

Call delivery to subscriber 103 (e.g., on wireline 106) is as follows in accordance with the invention. When a call from an originator (for example, from the PSTN) is received by the PBX (11), for wireline subscriber 103, the PBX (11) routes the call to wireline 106 as in the prior art. The WIB (12) detects a seizure (ring signal) for wireline subscriber 103 (on wireline 106) and begins a time delay. After a fixed delay the WIB (12) determines the corresponding mobile phone number of wireless subscriber 20 and passes this information to signaling interface 13 via I/O controller 203 in the form of the actual signaling protocol (e.g., the HDLC link protocol).

Signaling interface 13 then generates a paging message which is sent, via signaling links 100, to all base stations 15-18 for transmission to wireless subscriber 20. If one of base stations 15-18 is busy handling an existing call, the busy base station will discard the information. If a base station (15-18) is idle, it will transmit the page as part of a control channel stream along with a system identification code to which wireless subscriber 20 attaches an association. All base stations (15-18) may carry the same identifier, or different base stations may carry unique identifiers so as to differentiate a service or coverage areas. The wireless system also supports sleep-mode operations for idle subscriber units (20-22).

While signaling information is being routed to base stations 15-18, the PBX 12 receives information from the PSTN as it would for any wireline call, and sets-up the call accordingly. The information is routed, through TSI 218, to the base stations 15-18 via subscriber links 101. Upon receipt, base stations (15-18) intercept the ring signal while continuing to monitor the radio-frequency (RF) channel for a response to the page.

Wireless subscriber 20, upon receipt of the page, responds on an RF channel corresponding to an idle base station (15-18) within the system (10). The idle base station (e.g., 17) which

receives the response, from wireless subscriber 20, will direct WIB 12 to assign the appropriate line (110) from subscriber links 101 to be interconnected with the appropriate line (106) from wireline group 104 via TSI 218. At such time as the interconnect (between 106 and 110) is complete the now-communicating base station (17) sends an alert to wireless subscriber 20, resulting in a ring signal. When wireless subscriber 20 answers the call, the now communicating base station (17) will send an off-hook signal by way of subscriber links 101 (via WIB 12) to PBX 11 so as to provide the final connection and establish communication from the originator to wireless subscriber 20.

Call origination from wireless subscriber 20 to a destination (for example at the PSTN) is accomplished as follows. When not in use, wireless subscriber 20 resides on an idle channel that is transmitting idle protocol. Wireless subscriber 20 monitors the protocol until such time as the protocol is lost or wireless subscriber 20 begins placing a call. At such time as base stations 15, 16, 17, or 18 detect an origination attempt, by wireless subscriber 20, the corresponding base station 15, 16, 17, or 18 will drop the idle channel protocol and connect through to the PBX 11 via WIB 12, and more specifically, via signaling links 100. PBX 11 will prepare to receive the call from wireless subscriber 20 by connecting subscriber 20 from wireline group 104 to base station 15, 16, 17, or 18 via the appropriate line of subscriber links 101. At this point, wireless subscriber 20 can send dialing information in one of two ways.

In the first method, the origination message, sent by wireless subscriber 20, does not contain calling information and the origination message simply seizes an RF channel for a call. In this case, the corresponding base station 15, 16, 17, or 18 connects to PBX 11 by way of subscriber links 101 and waits for a dial-tone. Upon hearing a dial-tone, wireless subscriber 20 begins using any standard dialing protocol, such as dual-tone multi-frequency (DTMF)

In an alternative method, a base station 15, 16, 17, or 18 receives all the necessary calling information in the origination message. The corresponding base station 15, 16, 17, or 18 then goes off-hook. Upon receipt of a dial-tone from PBX 11, the corresponding base station 15, 16, 17, or 18 couples to wireless subscriber 20 and, at this point, the call may proceed as a normal wireline call

Channel selection, in accordance with the invention, and for assignment to the wireless subscriber (20), is performed by the processor (206) based upon measurements performed by the scan receiver (19). Under the preferred embodiment of the invention, the processor (206) directs the scan receiver (19) to scan channels, also used by the local cellular radiotelephone system, for purposes of identifying channels usable within the PBX wireless system (10). The processor (206) directs such scanning through commands generated within the processor (206) and transferred to the scan receiver controller (14) through the I/O controller (203) and signaling interface (13). The scan receiver controller (14), in turn, directs scanning of channels by the scan receiver (19) based upon commands received from the processor (206).

The scan receiver (19), upon scanning channels, returns a signal quality factor (such as a received signal strength indicator (RSSI)) to the processor (206), through the scan receiver controller (14) for each scanned channel. Signal quality factors are returned, along with a channel identifier, to the processor (206) through the signaling interface (13) and I/O controller (203).

The returned signal quality factors are compared, within the processor (206), with a threshold value. Channels having a signal quality factor exceeding the threshold are deemed to be usable channels within the wireless system (10). A list of usable channels is created within the data store (209) of the WIB (12).

Upon receipt of a page response (or upon receipt of a request for service) the processor (206) may select a usable channel from the list within data store (209) for assignment to the wireless subscriber (20-22). In advance of assignment the processor (206) may direct the scan receiver (19) to again scan the channel in anticipation of assignment. Channels that are found usable are assigned. Channels that are found not to be usable are removed from the list.

Channel scanning may also occur on channels used by the base stations (15-18) for the transmission of control information. Such scanning would occur at regular intervals to insure reliable operation of the wireless PBX system (10). Upon detection of interferers base stations (15-18) would change channels for transmission of control information.

Channel scanning and reuse of cellular channels within the PBX wireless system (10) beneficially allows for improved communication within localized area such as shopping malls, factories, or sports facilities. Such reuse by private systems offers the advantage of mobile communication in areas that by their nature may limit interference to nearby cellular systems. Such limited interference occurs because of the use of distributed base stations antennas and low power levels between base station and wireless unit. Where such private use is provided by base stations on different floors of the same building, and limited by power levels and antenna facilities, the private system may coexist on the same channel or set of channels within the same system without significant mutual interference within the private system or the local cellular system.

Claims

1. In a wireless private branch exchange communication network located within a service coverage area of a cellular communication system and reusing cellular communication resources, a method of identifying network communication resources, such method comprising the steps of: measuring a signal quality factor of a cellular system communication resource; comparing the measured value with a threshold value; and when the measured value exceeds the threshold, selecting the communication resource as a network communication resource.

2. The method as in claim 1 further including repeating the measurement, comparison, and selection for each communication resource within a selected spectrum.

3. The method as in claim 2 further including transferring an identifier of selected communication resource to a network controller of the wireless communication network.

4. The method as in claim 1 further including transferring, by a network controller of the wireless communication network, an identifier of a communication resource to a scan receiver.

5 The method as in claim 4 further including measuring, upon receipt of the identifier, the signal quality factor of the communication resource by the scan receiver.

6. The method as in claim 5 further including transferring the measured signal quality factor of the communication resource back to the network controller.

7. In a wireless private branch exchange communication network located within a service coverage area of a cellular communication system and reusing cellular communication resources, an apparatus for identifying network communication resources, such apparatus comprising: means for measuring a signal quality factor of a cellular system communication resource; means for comparing the measured values with a threshold value; and means for selecting the communication resource as a network communication resources when the measured signal quality factor exceeds the threshold.

8. The apparatus as in claim 7 further comprising means for repeating the measurement, comparison, and selection for each communication resource within a selected spectrum.

9. The apparatus as in claim 7 further comprising means for transferring an identifier of selected communication resources to a network controller of the wireless communication network.

10. The apparatus as in claim 7 further comprising means for transferring, by a network controller of the wireless communication network, an identifier of a communication resource to a scan receiver.

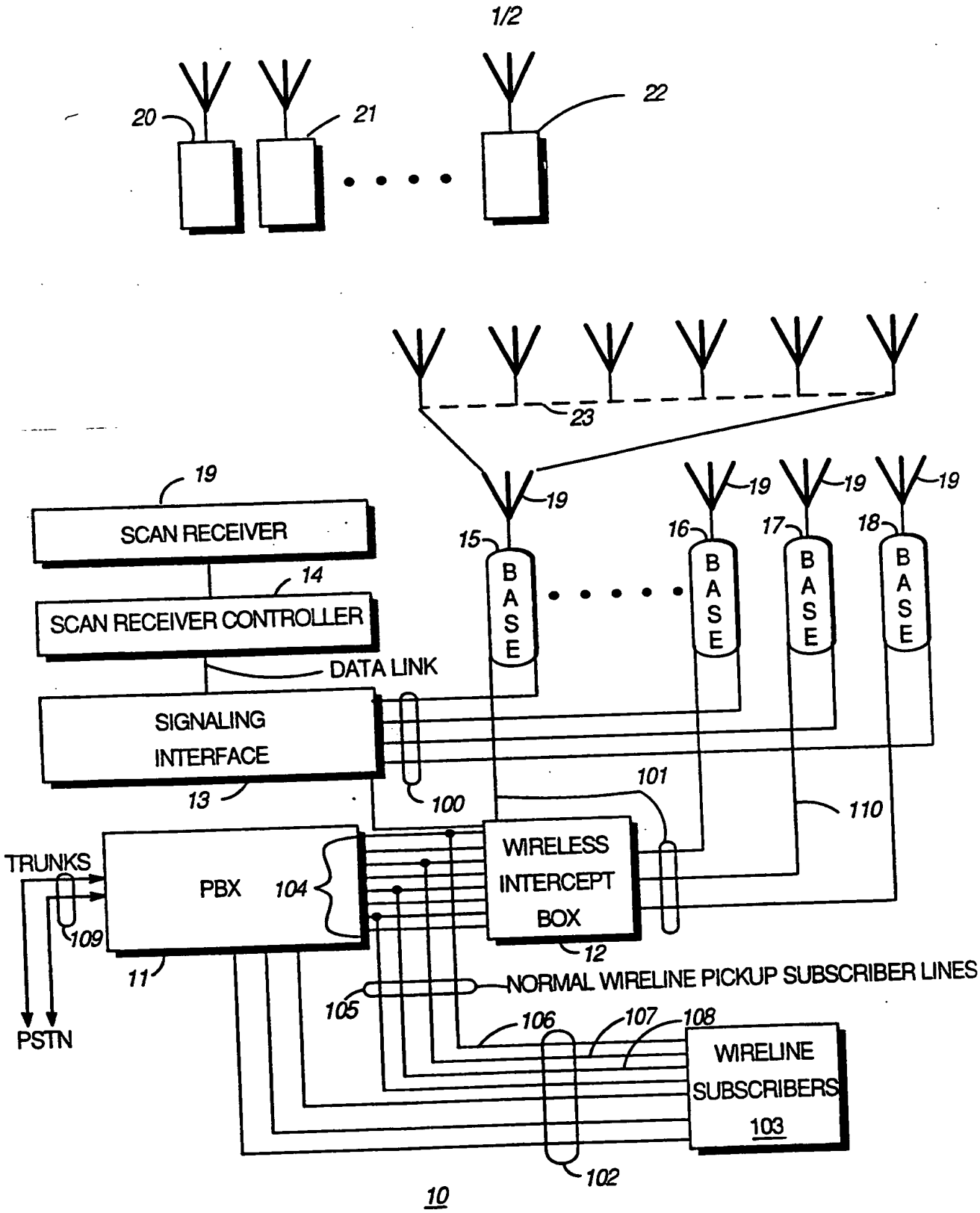
20
21
22
23
19
SCAN RECEIVER
14
SCAN RECEIVER CONTROLLER
DATA LINK
SIGNALING INTERFACE
13
15
16
17
18
BASE
100
101
110
TRUNKS
PBX
104
109
11
WIRELESS INTERCEPT BOX
12
NORMAL WIRELINE PICKUP SUBSCRIBER LINES
105
106
107
108
WIRELINE SUBSCRIBERS
103
102
PSTN
10

FIG.1

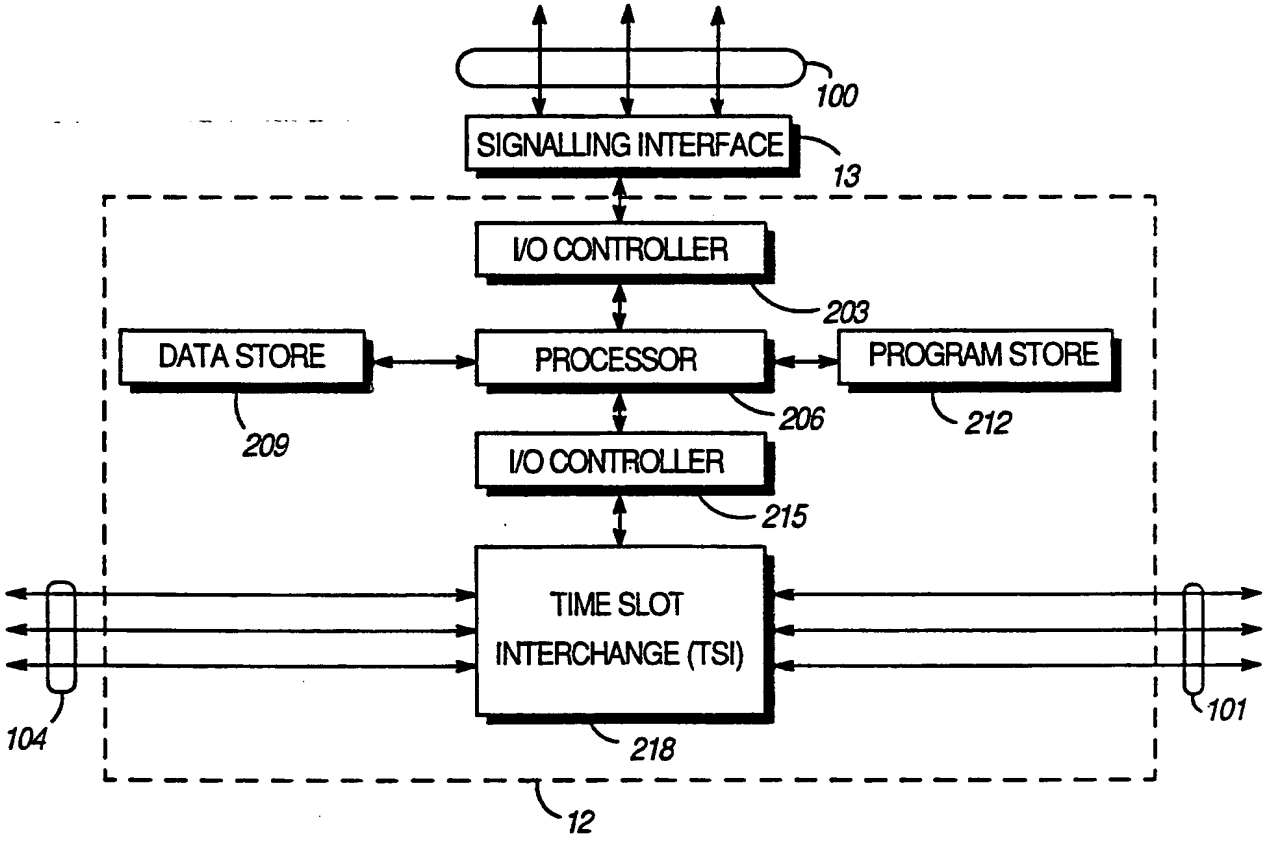
100
SIGNALLING INTERFACE
13
I/O CONTROLLER
203
DATA STORE
PROCESSOR
PROGRAM STORE
209
206
212
I/O CONTROLLER
215
TIME SLOT
INTERCHANGE (TSI)
218
104
101
12

FIG.2

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/06226

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :H04M 11/00
US CL :379/59
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 379/59; 455/33.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 4,790,000 (KINOSHITA) 06 December 1988 figures 1, 2, 5, #20, column 4, lines 5-16.	1-10
Y	US, A, 5,040,238 (COMROE, et al.) 13 August 1991 figures 5-8, #16, 14, 100A.	1-10
A, P	US, A, 5,210,786 (ITOH) 11 May 1993	1-10
Y, P	US, A, 5,212,805 (COMROE, et al.) 18 May 1993 figures 1-6, 9, #20, 123, 221, 222, 224, 400.	1-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
10 August 1993

Date of mailing of the international search report
01 SEP 1993

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Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/06226

B. FIELDS SEARCHED
Electronic data bases consulted (Name of data base and where practicable terms used):

APS search items: radiotelephone, mobile telephone, network, reusing, signal quality, measured value, communication resource, cellular telephone, coverage, portable telephone, private branch exchange, cordless telephone, personal telephone, radio telephone, communication system, resource table